NOAA Aeronomy Laboratory Frost Point Instrument

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Figure 1. Summary of the relationship between stratospheric measurements assessed in the SPARC report . The symbols give the direct percentage difference from HALOE, and the horizontal lines show the range of the indirect comparison. Each tick mark is 1%, and the placement for HALOE is indicated by the dotted line. AL is the NOAA aircraft Lyman □ instrument. CMDL is NOAA's balloon frost point hygrometer. The differences in this report are the incentive for the continued inter comparisons and multiple water measurements.

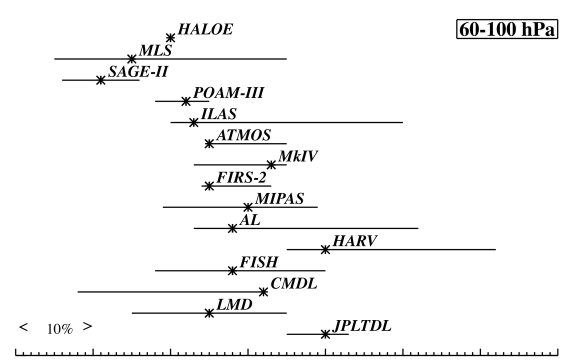
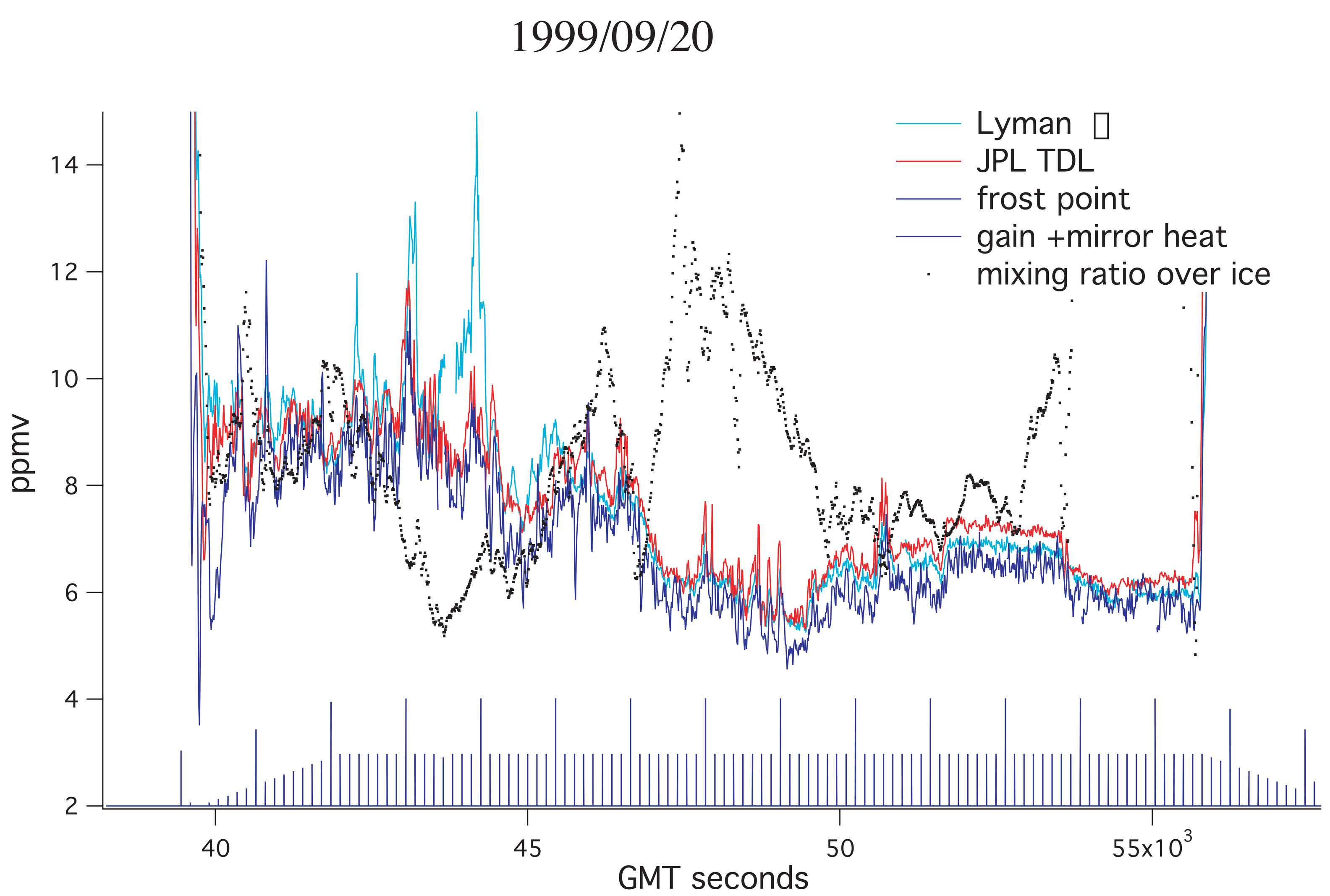
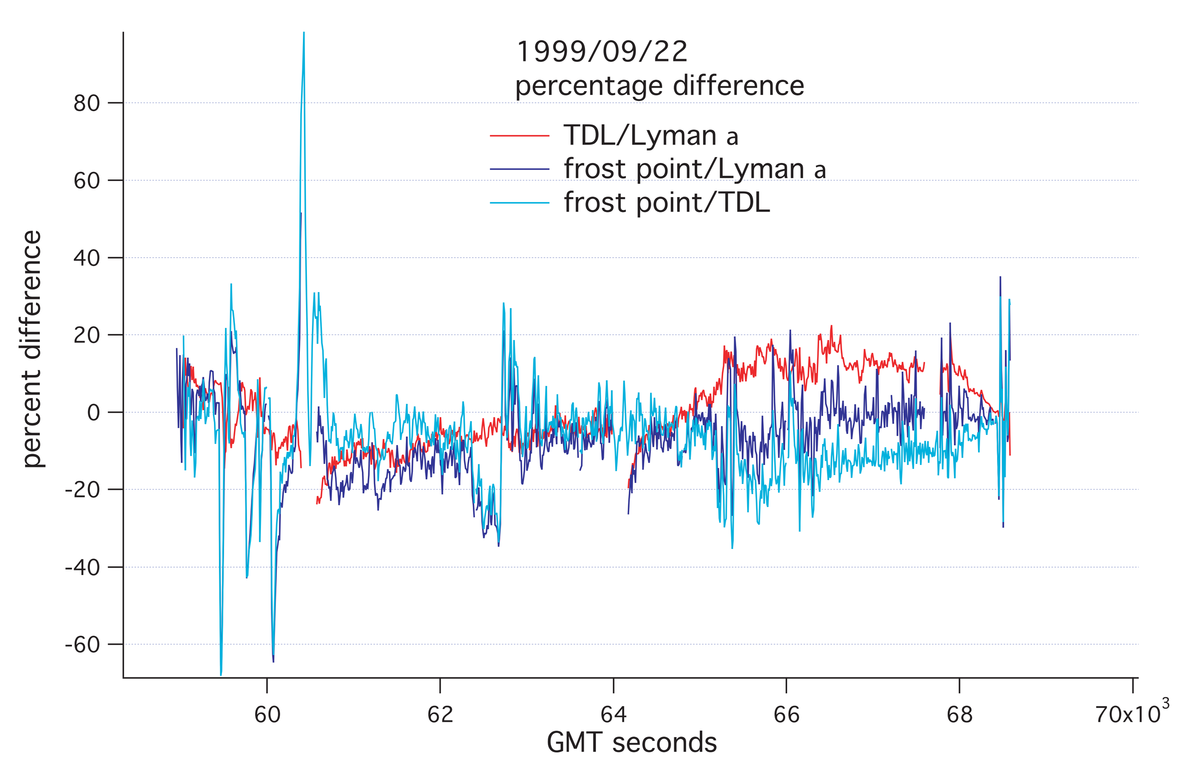


Figure 2. This flight demonstrated that the response time of the frost point instrument was faster than we had expected. Faster flow with turbulent transport improves the response time compared to slower laminar flow. This flight passed through a cloud. The frost point instrument was not warm enough to evaporate the ice.



GMT seconds

Figure 3. This flight clearly shows Lyman □ out gassing and frost point control errors on ascent. The difference between the TDL and Lyman □ on descent is also visible. The new frost point instrument was built with the hope of resolving some of the long term drifts between instruments.



Photograph of the Aeronomy Lab Frost Point Instrument under the wing of the WB-57

The new design has several differences from the first instrument.

There are two channels. One blue LED channel to maximize scatter from the frost and matched to the thermally insensitive wavelength of the detector. The second 2.7 micron LED channel is near the strong absorption of ice and the minimum reflectance of the Christiansen effect. The 2.7 micron channel will work for water, clear ice and frost.

The mirrors are 0.5 mm thick diamond. The heaters are thin film kapton and nichrome traces bonded between the diamond and a copper block. Thin film Platinum RTDs are epoxied to the face of the mirrors .The platinum is only separated from the mirror face by thin thermally conductive epoxy. The intent was to minimize the thermal mass and improve the response time. The impulse response is about six degrees per second.

A Sterling cycle cooler replaces the liquid nitrogen dewar. The Sterling cooler that we had and had tested in the lab was a low cost cooler for the communication industry. The cooler has a unconstrained resonant piston. This piston self destructed in flight. There were also electrical shorts that destroyed boards. One option is a sterling cooler designed for the Euro Fighter. The piston in this cooler is constrained by a flex bearing . The liquid nitrogen provided about 50 watts of cooling. The sterling cooler can pump about 10 watts. The smaller thermal mass and lower thermal leaks help make up for the lower power.

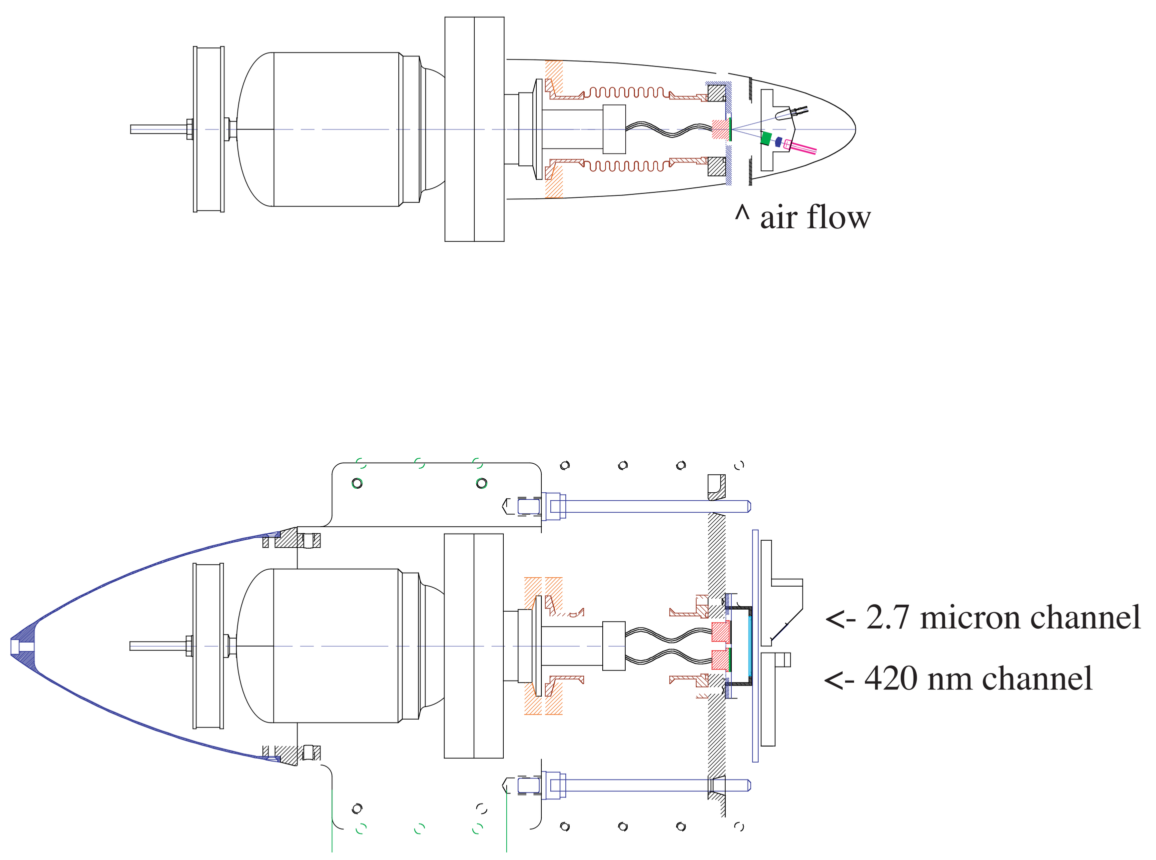
The inlet is much shorter and colder. The leading aerodynamic shape is canted to provide higher pressure on the lower side and provide flow across the mirror and separate the larger particles. The inlet structure is not heated and is at the stagnation air temperature.

The measurement errors are
pressure @ 50 mb < .05%
temperature +/- 0.05 degrees

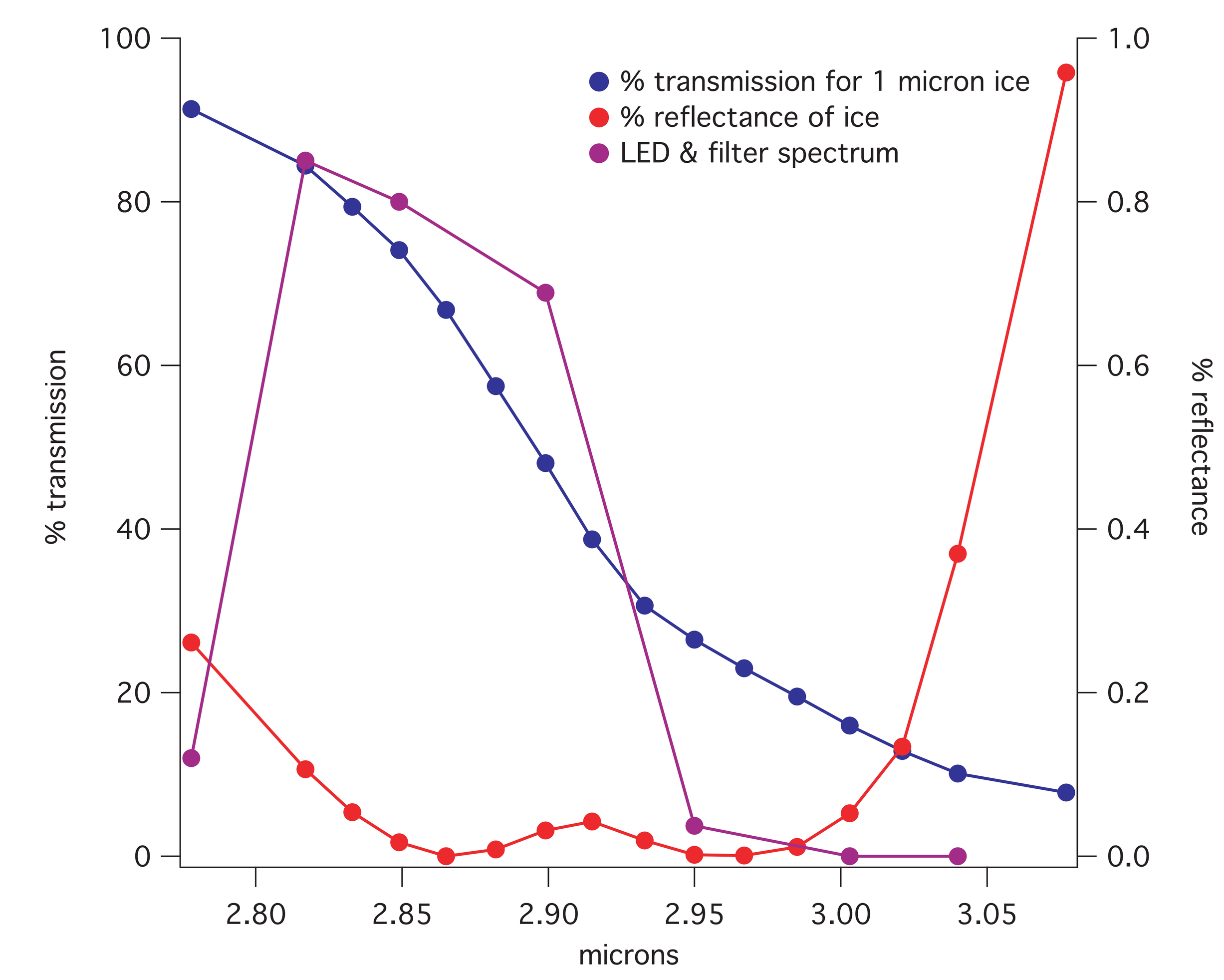
The temperature error is the equivalent of a 0.2% change in vapor pressure over ice,
The NBS estimated error in the vapor pressure measurement @ -90 C is +/- 0.4%.

The mirror assembly and flight electronics are calibrated against a standard platinum RTD.

Cut away view of the Sterling cooler, thermal coupling and optical benches



Christiansen effect for the 2.7 micron channel.



The LED and filter combination is not quite centered on the minimum.